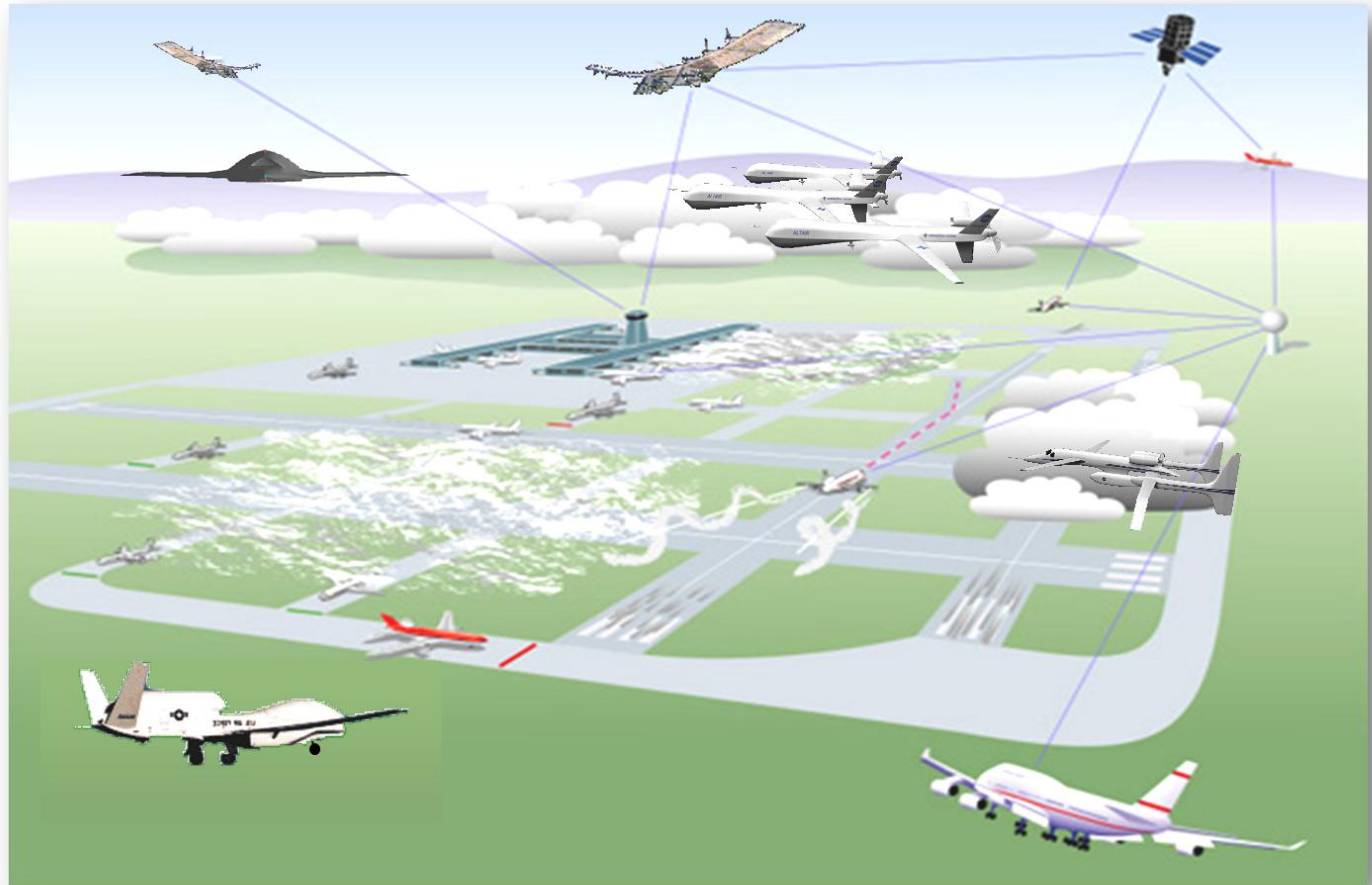
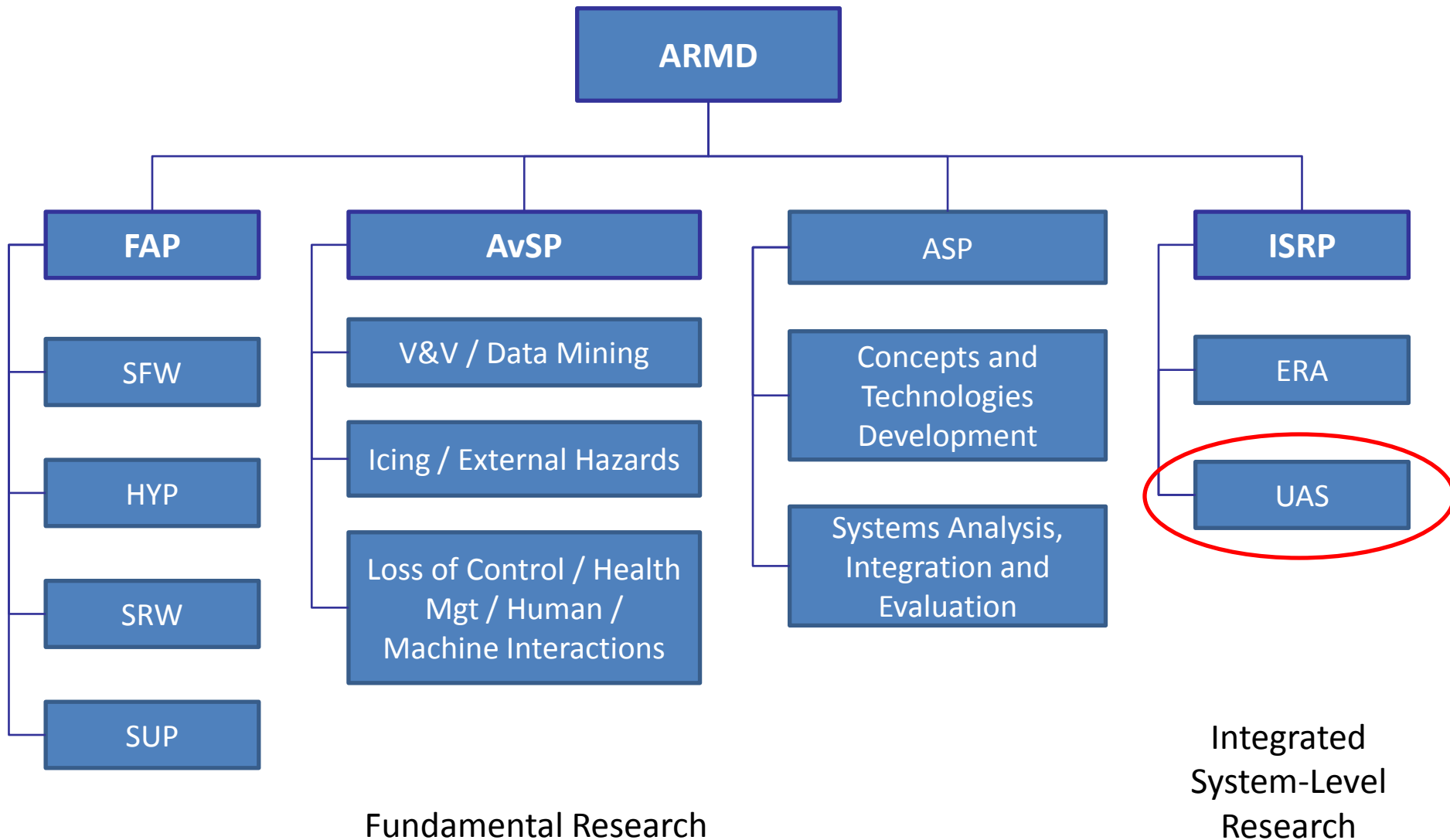
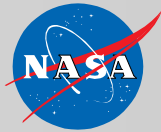


# Project Overview

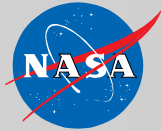


## UAS Integration in the NAS Project

# Advancing Technology Readiness in ARMD



# ISRP & Project Management Teams



## ***Program Office, NASA HQ, Washington, DC***

***Director***  
***Dr. Edgar Waggoner***

***Deputy Director***  
***Jean Wolfe***

***Systems Engineer &  
Integration Manager***  
***Steve Hirshorn***

***Program Integration Manager***  
***Annette Kempisty***

***Technical Program Management (on detail from DFRC) –  
Davis Hackenberg***  
***Program Support (LMI Contract) – Beverly Floyd***  
***Program Support (InDyne Contract) – Linda Phipps***  
***Administrative Assistant (MSO) – Vickie Smith***

***Project Execution***  
***LaRC - NASA Langley***  
***GRC - NASA Glenn***  
***ARC - NASA Ames***  
***DFRC - NASA Dryden***

## ***Environmentally Responsible Aviation (ERA) Project***

***Host Center – LaRC***

***Project Manager***  
***Dr. Fay Collier, LaRC***

***Deputy Project Manager***  
***Gaudy Bezos-O'Connor, LaRC***

***Chief Engineer***  
***Mark Mangelsdorf, DFRC***

***Chief Technologist***  
***Tony Washburn, LaRC***

## ***UAS Integration in the NAS Project***

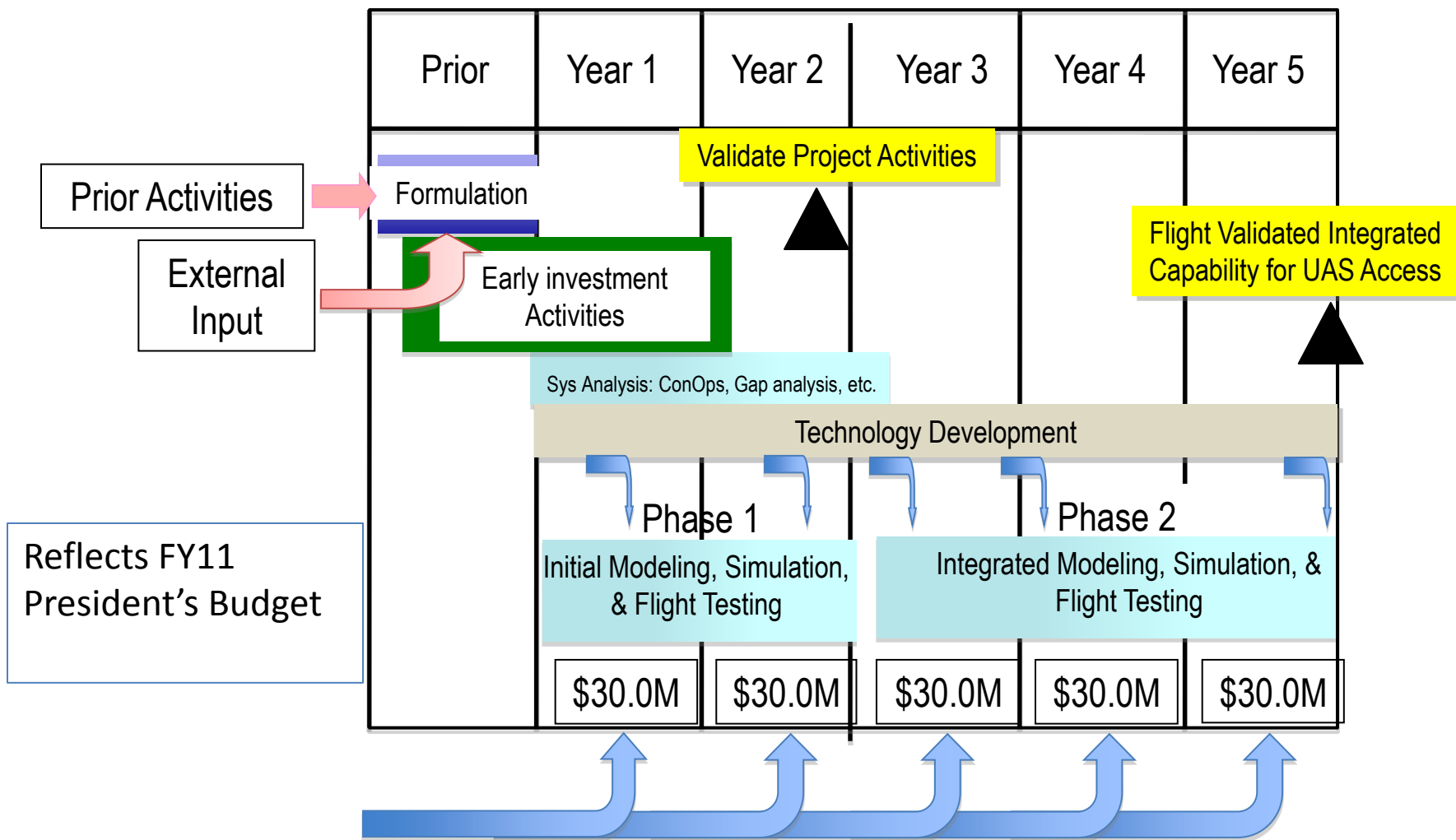
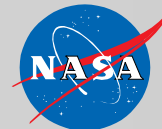
***Host Center - DFRC***

***Project Manager***  
***Chuck Johnson, DFRC***

***Deputy Project Manager***  
***Robert Sakahara, DFRC***

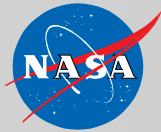
***Chief Systems Engineer  
(Acting)***  
***Debra Randall, DFRC***

# UAS Integration in the NAS Project Flow



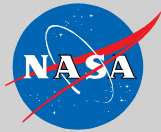
Technical input from Project technical elements, NRAs, Industry, Academia, Other Gov't Agencies

# Project History



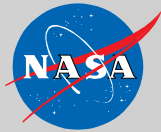
- Planning/Advocacy within Agency and Administration from January, 2009 to February, 2010
- FY11 President's Budget released February, 2010
  - New Project established at \$30M per year
- NRC Meeting of Experts accomplished on August 5, 2010
- Formulation Review accomplished October 21, 2010
- Acquisition Strategy Panel/Acquisition Strategy Meeting accomplished October 22, 2010
- Delta Formulation Review accomplished on December 16, 2010
- Project start delayed during Continuing Resolution
- **Project received funding on May 9, 2011**

# **UAS NAS Access Activities Initiated Prior to Official Start**



**These efforts will provide immediate Benefits to the UAS Community**

- **American Recovery and Reinvestment Act (ARRA) tasks**
- **Roadmap work**
- **NASA Research Announcements (NRAs)**
- **Small Business Innovative Research (SBIR) Subtopics**



# ARRA Tasks

**\$6.75M in ARRA funds were leveraged to provide immediate benefits to the Project and JPDO**

- **Tasks:**

- Consolidated ConOps
- UAS State of the Art in today's NAS
- Gap Analysis, Consolidated ConOps against today's NAS
- NextGen UAS ConOps
- Modeling and Simulation Infrastructure and tools development
- Communication and Avionics infrastructure Improvements

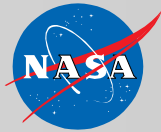
**All tasks completed**

**The Gap Analysis was updated to look at the NextGen ConOps as well**

**Outputs from first four tasks have been delivered to the FAA and JPDO**

**The last two tasks produced outputs to enhance Project tools and infrastructure**

# Roadmap Work

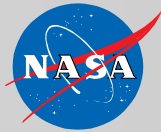


- **JPDO**

- Working with JPDO to develop a research and development roadmap for UAS access to the NAS due to OMB by the end of FY11. This research and development roadmap will provide the foundation for a technology roadmap necessary for the overall National Roadmap for UAS access into the NAS and NextGen.

- **FAA**

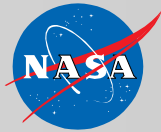
- Working with FAA and key stakeholders to define success and to ensure that a National Roadmap is created which includes (at a minimum) policy, procedures, and technology. These areas of concentration need to be integrated to show all activities required for UAS to be safely integrated into the NAS and NextGen.



# NRA Tasks and SBIR Subtopics

- **\$15.0M in NRA UAS solicitations will be awarded to supplement project objectives**
  - ARMD initiated tasks in five specific areas
    - Modeling and Simulation
    - Separation Assurance and Sense and Avoid
    - Systems Analysis
    - Certification
    - Test Techniques
  - SMD initiated tasks under ROSES process focusing on sensor development
  - Awards anticipated in August, 2011
  
- **One SBIR Subtopic for UAS Integration in the NAS**
  - Technology areas addressed
    - UAS Model Construction from Realtime Surveillance Data
    - Distributed System for Rapid Collection of Human-in-the-Loop Simulation Data
    - Certified control and non-payload communications (CNPC) system
    - System for Rapid or Automated UAS Flight Planning

# UAS Integration in the NAS



## Vision

- A global transportation system which allows routine access for all classes of Unmanned Aircraft Systems

## Mission

- Utilize integrated system level tests in a relevant environment to reduce technical barriers related to the safety and operational challenges of Unmanned Aircraft Systems (UAS) National Airspace System (NAS)

- Work with key stakeholders to define necessary deliverables/products to help enable UAS access to the NAS

## Technology Development Areas

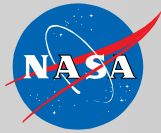
- Separation Assurance, Human Systems Integration, Communications, Certification, Integrated T&E

## Key Stakeholders

- UAS ExCom, FAA, JPDO, Standards and Regulatory Organizations

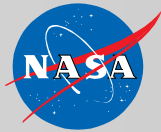
Separation Assurance	Human Systems Integration	Communication	Certification
Assess the applicability to UAS and the performance of NASA NextGen separation assurance concepts in flight tests with realistic latencies and trajectory uncertainty	Develop a research test-bed and database to provide data and proof of concept for GCS operations in the NAS	Develop data and rationale to obtain UAS frequency spectrum allocations	Define a UAS classification scheme and approach to determining airworthiness requirements (FAR xx.1309) applicable to all UAS digital avionics
Assess how NextGen separation assurance systems with different functional allocations perform for UAS in mixed operations with manned aircraft	Coordinate with standards organizations to develop human factors guidelines for GCS operation in the NAS	Develop and validate UAS secure safety critical C2 test equipment	Provide recommendations for hazard and risk-related data collection to support development of type design criteria and standards
Integrated Test and Evaluation Human-in-the-loop Simulations and Flight Test Series			

# Project Brief Acronym List



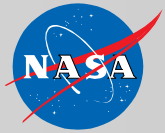
ARC - Ames Research Center  
ARMD - Aeronautics Research Mission Directorate  
ARRA - American Recovery and Reinvestment Act  
ASP - Airspace Systems Program  
AvSP - Aviation Safety Program  
C2 - Command and Control  
CNPC - Control and non-payload communications  
ConOps - Concept of Operations  
DFRC - Dryden Flight Research Center  
ERA - Environmentally Responsible Aviation  
FAA - Federal Aviation Administration  
FAP - Fundamental Aeronautics Program  
FAR - Federal Aviation Regulation  
GCS - Ground control Station  
GRC - Glenn Research Center  
HYP - Hypersonics Project  
ICAO - International Civil Aviation Organization  
ISR - Integrated Systems Research Program  
JPDO - Joint Planning and Development Office  
LaRC - Langley Research Center  
NAS - National Airspace System  
NextGen - Next Generation Air Transportation System  
NRA - NASA Research Announcement  
OGA - Other Government Agencies  
ROSES - Research Opportunities in Space and Earth Sciences  
RTCA - [www.rtca.org](http://www.rtca.org)  
SBIR - Small Business Innovative Research  
SFW - Subsonic Fixed Wing Project  
SMD - Science Mission Directorate  
SRW - Subsonic Rotary Wing Project  
SUP - Supersonics Project  
UAS - Unmanned Aircraft Systems  
V&V - Verification and Validation

# Project Technical Objectives



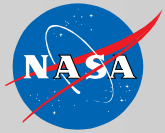
- Phase 1
  - Developing a gap analysis between current state of the art and the NextGen UAS ConOps
  - Working with Federal Aviation Administration and key stakeholders to define success and to ensure that a National Roadmap is created which includes policy, procedures, and technology
  - Validating the key technical areas
  - Conducting initial modeling, simulation, and flight testing activities
  - Completing Subproject Phase 1 deliverables (spectrum requirements, comparative analysis of certification methodologies, etc.) and continue Phase 2 preparation (infrastructure, tools, etc.)
- Phase 2
  - Providing regulators with a methodology for developing airworthiness requirements for UAS, and data to support development of certifications standards and regulatory guidance
  - Providing systems-level, integrated testing of concepts and/or capabilities that address barriers to routine access to the NAS. Through simulation and flight testing, address issues including separation assurance, communications requirements, and human systems integration in operationally relevant environments

# Separation Assurance



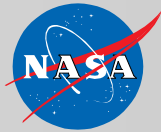
- **Goals**
  - Demonstrate NextGen algorithm effectiveness for UAS operations
  - Determine the efficacy of different separation assurance functional allocation paradigms for UAS in NextGen
- **Objectives**
  - Assess the applicability to UAS and the performance of NASA NextGen separation assurance concepts in flight tests with realistic latencies and trajectory uncertainty
  - Assess how NextGen separation assurance systems with different functional allocations perform for UAS in mixed operations with manned aircraft

# Separation Assurance



- **Technical Challenge**
  - **Safely and seamlessly integrate UAS into NextGen separation assurance**
    - Cruise speeds, turn rates, climb/descent performance different from manned aircraft
    - Different missions than manned aircraft
    - Communication and control latency
    - Transitions of control between humans and automation
    - Procedural compatibility with air traffic control system

# Human Systems Integration



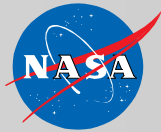
- **Goal**

- Develop the database, by instantiating proof of concept GCS, to work with standards organizations on recommended guidelines for GCS integration in the NAS

- **Objectives**

- Develop a research test-bed and database to provide data and proof of concept for GCS operations in the NAS
- Coordinate with standards organizations to develop human factors guidelines for GCS operation in the NAS

# Human Systems Integration



- **Technical Challenges**

- **Database and Proof of Concept:**

- Display airspace information without increasing workload
      - Address UAS characteristics that make them different from manned aircraft
        - » Limited in-situ sensory input
      - Assess human-automation interaction and responsibility between onboard automation and the aircraft operator

- **Human Factors Guidelines:**

- Develop standard against which to assess UAS ground control stations
      - Current UAS GCS interfaces are aircraft specific, non-standard
      - Lack of standardized airspace information displays

- **Goal**

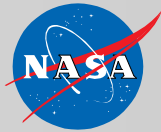
- Validate secure scalable robust datalinks within allocated frequency spectrum for UAS

- **Objectives**

- Develop data and rationale to obtain appropriate frequency spectrum allocations to enable the safe and efficient operation of UAS in the NAS
- Develop and validate candidate UAS secure safety critical command & control (C2) system/subsystem test equipment which complies with UAS international/national frequency regulations, ICAO Standards and Recommended Practices, and FAA/RTCA Minimum Operational Performance Standards/Minimum Aviation System Performance Standards for UAS
- Perform analysis to support recommendations for integration of safety critical C2 system and ATC communications to ensure safe and efficient operation of UAS in the NAS

- **Technical Challenge**
  - **Validate new UAS spectrum and data link communications to enable UAS integration in the NAS**
    - Currently, UAS are managed through exceptions and are operating using DoD frequencies, amateur bands, or unlicensed Instrument/Scientific/Medical frequencies. None of these frequency bands are designated for safety and regularity of flight
    - UAS require new frequency spectrum allocations and a new data communications system which is both secure and scalable

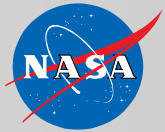
# Certification



- **Goal**
  - Recommend airworthiness requirements and type design criteria for UAS to facilitate safe operation in the NAS
  
- **Objectives**
  - Define a UAS classification scheme and approach to determining airworthiness requirements (FAR xx.1309) applicable to all UAS digital avionics
  - Provide recommendations for hazard and risk-related data collection to support development of type design criteria and standards

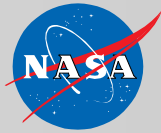
- **Technical Challenges**
  - **Airworthiness**
    - The current aircraft classification scheme and corresponding airworthiness requirements are not directly applicable to the full range UAS
  - **Hazard and Risk-Related Data**
    - Little UAS specific data (incident, accident, and reliability) exists in a civil context to support development of standards and regulations.

# Integrated Test & Evaluation



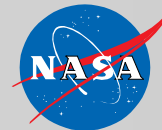
- **Goal**
  - Integrate and test concepts, technologies, and capabilities in relevant environments that can enable UAS access to the NAS
- **Objectives**
  - Integrate and test mature concepts from the technical elements to demonstrate and test viability
  - Evaluate the performance of the research in a relevant environment (full mission human-in-the-loop simulations and flight tests)

# Integrated Test & Evaluation



- **Technical Challenges**
  - Creation of an appropriate test environment
  - Integration of the technical research to probe and evaluate the concepts
  - Coordination and prioritization of facility and aircraft schedules

# Summary



**The goal of the UAS Integration in the NAS Project is to contribute capabilities that reduce technical barriers related to the safety and operational challenges associated with enabling routine UAS access to the NAS**

- **Leveraging Current NASA Investments**
  - UAS NAS Access Activities Underway will provide immediate benefits to the UAS community
- **Partnership Plan**
  - NASA has engaged key stakeholders in the planning of this project and will continue to do so to leverage assets of OGA's, industry and academia to execute plan
- **Technical Plan**
  - Technical elements have been vetted with stakeholders and are complementary efforts